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ABSTRACT

A study examined the types of individuals receiving on-the-job-training and the effect of such training on productivity and earnings. Two years of data from the Michigan Panel Study of Income Dynamics (an 11-year longitudinal study with a sample size of about 200 individuals) concerning the on-the-job-training, labor market experience, and income levels of household heads was used in the study. The final data sample included 1379 observations, with 19 percent of the respondents being female and 91 percent being white. The key variable of the study was the length of training for individual jobs. Data indicated that economic return plays a significant role in the determination of training. Women appear less likely to receive training for a given rate of return to this investment. While the hypothesis of discrimination against women and singles in their access to training cannot be rejected by this test, it appears that discrimination against blacks and the less educated in their access to training is not evident. Further research to refine the measures of the rate of return to training and to explore the mechanisms behind allocation of training is needed. (MN)

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# A New Measurement of On-the-Job Training:

# The Determination and Effect of Training

by

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## ABSTRACT

This study uses a new measurement of on-the-job training to study the effect of training on wage growth for different individuals, and the determination of which individuals receive training.

The empirical investigation attempts to test two alternative hypotheses about the training process. The first is an implication of human capital theory; that individuals make a cost-benefit evaluation of training alternatives and those individuals with the highest rates of return to training are the most likely to be trained. The second hypothesis suggests that discrimination and market segmentation play an additional role in limiting the access of training programs to women and minorities. The statistical analysis uses longitudinal data from the Michigan Panel Study of Income Dynamics to estimate a simultaneous equation model of the effects and determination of training.

The key results are that the economic return plays a significant role in the determination of training, but that other factors also matter. Women appear less likely to receive training for a given rate of return to this investment. The same is true for unmarried individuals. The hypothesis of discrimination against women, and singles, in their access to training can not be rejected by this simple test. However, it appears that discrimination against blacks or the less educated in their access to training is not evident in the data. These preliminary results justify further work to refine the measures of the rate of return to training and explore the mechanisms behind the allocation of training.

Introduction:

Perhaps the most important non-school learning setting is the workplace. During their lifetime, workers acquire a large fraction of their skill and knowledge through work, either by formal training and apprenticeship or by informal on-the-job training. Despite its significance, relatively little is known about the extent and effect of company training, chiefly because records have been inaccessible to university and government researchers.

Information on training would be extremely valuable in addressing the current crises in youth unemployment and labor productivity. Much of manpower policy is aimed at providing skills and training to workers, and these policies could be assisted in their design by the great experience of private trainers. This is especially true in light of a shift in manpower policy towards subsidization of private efforts to hire and train on the evidence that the most effective way to learn skills for a job is while on that job.

Current plans to assist unemployed youth stress the integration of schooling and training. Schools provide individuals with basic skills that help determine their employability, their trainability, and their overall success in life. Similarly, training reinforces the skills learned in school and provides incentives for further learning. The new emphasis on school-work integration is spirited by the recent growth of vocational education and community colleges. Further information on training could allow educators to improve school programs, and also allow educators with their vast experience in teaching skills to assist in these training efforts. The involvement of educators in training could serve as a new market for teachers and administrators during these times of declining enrollments.

The answers to two important questions will emerge from this study: (1) What kinds of workers undertake training of a particular type and duration?, and (2) What is the effect of training on the creation of skills that augment the worker's productivity and earnings? The first answer creates information on the accessibility of training programs to workers of different races, sexes, and education, and

the decision process by which workers select jobs with training. There is great importance to this issue in light of the great difficulty that minority groups, youth and women have in gaining entrance to good jobs. There is some evidence that much of the earning differential between blacks and whites is caused precisely because of the differences in the opportunities for training and advancement to these groups. (Lazaer, 1979) Understanding the decision-process of workers in selecting jobs with training, and that of firms in selecting workers to train would be valuable to policy-makers in their quest to increase employability and productivity in the workplace.

One aspect of this question should be of special interest to educators. Do workers with more education receive more job training? It has been argued that educated workers receive more training because of their demonstrated ability and the value of their education in acquiring new skill. If this were true, there would be a strong argument for compensatory education, since education would be so important in determining the skill and economic position of the worker throughout his life. Training deficiencies would reinforce educational deficiencies. However, training could enrich the skills of workers who have not received sufficient education. Training itself could serve as a form of compensatory education. If education and training reinforce each other, then there would be a strong argument for the active role of educational policy-makers in the availability of training.

The second answer provides a measurement of the effect of training on the creation of skills that augment productivity and earnings. This would be useful in order to isolate the effectiveness of various training strategies. Economists have looked at training as an investment, in the form of time and out-of-pocket costs, for the future benefit of increased earnings. The study can be used to explore the cost-benefit comparison that workers and firms make in deciding the type and extent of training. The effect of training on wage growth can be measured for different groups of workers in

order to determine the extent that training has created marketable skills that augment the wage.

There are advantages to studying these questions simultaneously. For economic theory would suggest that workers who are likely to experience the greatest gains in productivity from training would be the ones most likely to be trained.

The empirical investigation presented here will attempt to confirm this implication by measuring the expected economic return to training for an individual and then estimating the effect of expected return on the propensity for training of the individual. However it is possible that other factors besides economic return matter in the determination of who becomes trained. For example, there are many who claim that discrimination limits access to training for blacks, women, and the less educated. These claims can in theory be tested. If there is discrimination then the discriminated group should have a lower propensity to be trained at the same measured economic return.

The extent that the propensity to be trained is a result of differences in the economic return to training or a result of discrimination would have important implications for policy. First, the responsiveness of training to economic return is an important ingredient in the effectiveness of any government policy aimed at the encouragement of training based on subsidization or tax credits of private employers. Secondly, if discrimination is the cause, a large government involvement in affecting the training process may be justified, whether through affirmative action, subsidization of specific groups, or public training. Finally, the effort to improve the job and income prospects of certain groups can be assisted by knowledge of whether the impasse in is the access to training programs rather than at other links in the chain of upward mobility.

Labor economists have based much of their explanation of wage differentials among workers on the differing extent of the acquisition of skill during schooling and at the workplace and the value of these

skills in worker productivity (Becker, 1975). Despite the sheer quantity of research in this area, most studies are severely limited by the poor information regarding the extent and kind of training experienced by workers. Typically, the implausible assumption is made that formal education is measured by years of schooling and learning on the job by a weak approximation based on age (Mincer, 1974).

While this study will utilize some of the methodology of economic studies of training, it will improve upon it by utilizing a far better measure of training. The Michigan Income Dynamics Panel Survey has recently added detailed questions on the training that workers acquire at the workplace. These questions provide a valuable source of information on the actual training acquired by workers on their jobs, the length of the training, and the type of training.

The outline of this paper is as follows: Section I presents a critique of the economic literature on on-the-job training and the departure of this study from previous ones. Section II describes some theory concerning on-the-job training and how it relates to the pattern of wage growth. In Section III, an econometric specification is provided involving the simultaneous explanation of the determination of training and its effects on wage growth. Section IV describes the data and Section V presents the empirical results. The key results are that training is responsive to differences in the rate of return to training, though there is evidence that the access to training is limited to women and single individuals of either sex by discrimination. The last section presents some suggestions for further research, conclusions, and some implications of this study for policy.

Section I

Literature Review:

Interest in on-the-job training among economists was sparked by attempts to explain the growth of earnings with work experience. One explanation is provided by human capital theory (Becker, 1964, Mincer, 1974). This theory treats on-the-job training as an investment in skill that yields greater productivity and earnings to the worker. Work experience is treated as a proxy for training on-the-job, and as the worker accumulates human capital with work experience wages rise with experience. Wage differentials among individuals are attributed to differences in the rates of investment in human capital. This interpretation of on-the-job training emphasizes free choice among alternative jobs. Workers choose among jobs with differing amounts and kinds of training. Since training leads to future productivity and wages, workers will trade-off current wages and training in selecting jobs.

An alternative explanation of wage differences among workers is suggested by market segmentation theories (Piore and Doeringer, 1971, Ginzberg, 1979). These theories assume that certain groups are denied access to jobs with high pay and training because of discrimination and other barriers to mobility. Markets become segmented into non-competing groups. The implication for training is that workers who have a high potential benefit from training are not being trained, resulting in inefficiency and inequality.

Attempts to isolate and test human capital theory from market segmentation theories have been limited because of the inability to measure all aspects of the characteristics of a worker or the characteristics of his job. Statistical models have depended on measuring the age-earnings patterns. Direct measures of training have only recently been used. Because of these data problems it has been possible to detect the existence of wage differentials, but it is impossible to know their true cause.

The conflict between these two groups of theories has been underlying the discussion of several key issues in wage determination. There are three empirical "facts" that have emerged from wage

analysis whose explanation has been attributed to differences in the on-the-job training received by different population subgroups. These are: (1) the lower wage growth of blacks relative to whites; (2) the lower wage growth of females relative to males; and (3) the faster wage growth of college educated workers.

The slower wage growth of blacks relative to whites has been substantiated by a number of cross-sectional and longitudinal studies (Welch, 1973; Smith and Welch, 1977; Lazear, 1979; Hoffman, 1979). Using longitudinal data, Hoffman was able to measure wage growth for individuals by isolating "vintage" effects in the wages of different age groups. While these vintage effects are sizable, slower black wage growth relative to whites was especially pronounced for young workers. Lazear (1979) has shown that the measured difference in rate of wage growth has grown over time and attributes this to increased differences in the investment rate of blacks and whites in on-the-job training.

There are two hypotheses explaining differences in on-the-job training investments among blacks and whites. The first hinges on differences in the costs and returns to those investments. It has been pointed out that because of differences in productivity, educational preparation, and labor participation that the benefits of training may be less for blacks. This explanation is perfectly compatable with the notion that previous discrimination is the source of these differences. The second view points to discrimination in the access to on-the-job training programs or access to jobs that use the training, or discrimination in capital markets that unnecessarily raise interest rates for blacks. This view is best developed in the market segmentation literature in which blacks are denied access to the good primary sector jobs with training and chances of promotion (Piore and Doeringer, 1971).

A similar argument has been applied to women. The flatter earnings profiles of women have been explained both by differences in on-the-job investments among men and women, and by discriminatory

occupational segregation. Mincer and Polachek (1974) demonstrated that the earnings profile of women could be explained by low rates of investment and the depreciation of skills because of irregular pattern of employment by women. Since many women and employers expect that jobs will be broken up by periods of child-rearing and non-market activity the incentive to invest in training is reduced. There is a causality problem here as low rates of investment and subsequent low pay will encourage labor market exit.

The unraveling of training, labor supply, and fertility decisions for women has been a complicated enterprise. Fleisher and Rhodes (1980) review many of these studies and present a simultaneous equation system explaining these decisions using individual data. It is clear that women with children face significantly slower rates of wage growth possibly as a result of reduced incentives to invest in on-the-job training.

Lastly, early researchers observed that more educated workers had steeper earnings profiles suggesting a more intensive investment in on-the-job training. This suggested that education was complementary with more post-school investments in human capital. One interpretation consistent with human capital theory is that education makes learning-on-the-job easier, the other is that factors such as ability or opportunity that cause greater investments in education are also related to on-the-job investments. On the other hand, a market segmentation interpretation would suggest that education serves as an extra credential in gaining access to good jobs, independent of any indication of skills or ability. The distinction between the two theories gets hazy when it is considered that education may provide information to potential employers about worker productivity in an uncertain environment.

Attempts to measure who gets training or the effects of training have been crippled by a lack of data on training in the private sector. Mincer attempted to measure the extent of training from age-earnings data, and the assumption that on-the-job training would have the same rate of return as other human capital investments, such as education. He concluded that on-the-job training was as important

in terms of resources spent as formal education. This has generated a large empirical literature following Mincer's methodology and this literature is systematically reviewed by Rosen (1977) and Blaug (1975).

The greatest weakness of that theory is the lack of a solid link between it and the empirical work that has supposedly supported it. This has been the source of greate debate and criticism. Previous empirical research has relied on several major and questionable assumptions. First, they assume that training is related functionally to the work experience of the individual. Often it is assumed that training intensity declines linearly with experience. Secondly, it is assumed that workers are in the labor force full-time since leaving school, allowing experience to be measured by age less school-leaving age. While some attempts have been made to actually measure experience, they have generally been weak. Thirdly, the pattern of training is assumed to be independent of the particular job that the worker holds. This assumption demands that the worker can move without cost from job to job.

The result of these assumptions is to create an amazing gap between the actual training experience of a worker and that which is assumed for him. Even if experience was correctly measured, there is a leap of faith, that training corresponds to it in the way assumed. In addition, this research has not tested the economic hypothesis that workers freely select training to gain income. While "human capital" theory is perhaps consistent with the data, the number of assumptions required have weakened its position to its critics.

There have been several recent studies that have made use of direct measures of on-the-job training in the Michigan Panel Study of Income Dynamics. Duncan and Hoffman (1979) use this measure to see which workers acquire training and measure the effect of training on wages. While they find blacks and women are not trained as much, they can not isolate the human capital explanation from that of discrimination. They do not explicity measure the rate of return to training for individual workers. They can not then test the hypothesis embedded in human capital theory that training decisions are based on a

calculation of the potential return to training. In addition, their methodology does not take into account the endogeniety of training in measuring the effect of training as implied by this type of economic decision.

Harvey Rosen (1981) recently used the same data set as this study to investigate the effects of taxation on on-the-job training decisions. He finds that workers with high marginal taxes are more likely to invest in training. He attempts to measure the internal rate of return to training and then usesthat to determine who gets trained. Several difficulties are encountered. First, he ignores the possible endogeniety of training in estimating the impact of training with possible sample-selection bias as a result. Secondly, he assumes that the effect of training on earnings is the same for all workers; the only variation in the internal rate of return will be a result of differences in time till retirement. Thirdly, the marginal tax rate is strongly related to a worker's earnings. The fact that training and marginal tax rates are postively related is not surprising because of the correlation between tax rates and earnings.

The strategy followed here departs from previous studies of on-the-job training and owes much to a study of college attendance by Rosen and Willis (1979). In their framework, workers compare the benefits and costs of college attendance in making their decision. They measure the effect of a college education on wages and wage growth simultaneously with the determination of college attendance. This corrects for sample-selection in the measurement of the effects of a college education. In turn, they can measure the extent that those that might benefit most from a college education attend college. The human capital investment decision is thus broken down into a comparison of benefits and costs and explicitly tested.

This study of training departs from previous investigations. While the same data and same explicit measure of training are used as studies by H. Rosen (1980) and Duncan and Hoffman (1979), there are several major improvements in methodology. First, the training decision

is broken down into a comparison of benefits and costs that force a consideration of the simultaneous determination of training with its effect. Those that increase their productivity the most from training are those that are the most likely to be trained. Secondly, the effect of training is allowed to vary among individuals creating additional variation in the rate of return to training among individuals. Thirdly, this study can approach the question of discrimination in the allocation of training because it is possible to control for the effect of the rate of return to training in this allocation process. Finally, the use of the longitudinal aspect of the data set improves the control for individual variation and increases confidence in the reliability of the resulting estimates.

Section II

Theory:

The basic idea is that on-the-job training is an investment that yields future benefits in terms of increased productivity and wages for the workers. Returns to that investment will differ among workers and over time. The rate of return will be compared to alternative investments available to the firm and worker, and only workers with rates of return to training higher than the rate of return to the best alternative will invest in on-the-job training.

The return to an investment in training depends upon the magnitude of benefits, the length of time the benefits are received, and the costs of investment. Suppose that for each hour of investment, the productivity and wages of the worker increases by $\Delta w$. Non-pecuniary benefits of training have been ignored. Wage benefits are received continuously over the time horizon of H years. This abstracts from the possibility that the future employment of a worker may not be continuous or known with certainty. In addition, if training is specific to an occupation or job, then the relevant time horizon will be the time of employment in jobs using the skill from the specific training. It is also assumed that workers can borrow and lend freely at the market rate of interest, I. The cost of training is the foregone earnings incurred because of the time taken up by training. That is, the worker's wage, w, for each hour of training. Tuition and other out-of-pocket cost of training are ignored. The net benefit of training will be the present value of the stream of benefits less costs. This is:

$$(1) \quad N = \Delta w \int_0^H e^{-it} dt - w = \frac{\Delta w(1-e^{-iH})}{I} - w,$$

where future benefits are discounted by the interest rate. Since the market rate of interest captures the return to alternative investments, workers will become trained only when the net benefit is positive.

A good measure of the rate of return to an investment in training is the internal rate of return. The internal rate of return is the interest rate, r, that brings the net benefits, N, to zero. This can be shown in the following expression by setting N equal to zero:

$$(2) \qquad \frac{\Delta w(1-e^{-rH})}{r} = w.$$

In the case of an infinite horizon, $H = \infty$, the internal rate of return equals $\Delta w/w$, the percentage change in wages with an hour of training. In the finite horizon case it is not possible to solve explicitly for the internal rate of return, but it is clear that the internal rate of return is an increasing function of the percentage change in wages with training and with the time horizon.

The internal rate of return will vary among individuals with changes in the effect of training on wages or the time horizon. If workers face alternative investments at the market rate of interest then workers will only accept training when their internal rate of return exceeds the market rate of interest. This is equivalent to the rule that workers train when they face a positive net benefit to training.

Thus workers with greater percentage increases in wages and longer horizons are likely to be trained. The longer time horizon for younger workers encouraging training is the common explanation of the faster wage growth of younger relative to older workers. The time horizon also will depend on the future employment of the worker and the generality of the skills learned while being trained.

In order to use this framework for purposes of estimation, a formulation developed by Mincer is used. Workers have potential wages at time t of $E_t$. This is the wage they could earn if they spend no time training. However, their actual wages, $w_t$, are less than their potential wages because of the time that workers devote to training on the job. If the workers use $k_t$ proportion of their time in training, then actual wages will be: $w_t = (1-k_t)E_t$. Foregone wages become: $k_tE_t$. Training results in the growth of potential wages at rate g for each unit of time in training, according to:

$$(3) \qquad E_t = E_{t-1}(1+gk_{t-1}).$$

Taking logarithm and using a standard approximation yields:

$$(4) \qquad \ln E_t \cong \ln E_{t-1} + gk_{t-1}.$$

Potential wages grow by g percent with each unit of time in training. Using the same approximation, the logarithm of actual wages is related to previous potential wages by:

$$(5) \quad \ln w_t \tilde{=} \ln E_{t-1} + gk_{t-1} - k_t.$$

Actual wages equal previous potential wages plus the gain from last year's training less the loss from this year's training time. Substituting $\ln w_{t-1} + k_{t-1}$ for last year's potential wages, we can get an expression for the change in the log of actual wages:

$$(6) \quad \ln w_t - \ln w_{t-1} \tilde{=} (1+g)k_{t-1} - k_t.$$

Percentage wage growth is related to the current and last year's training. If the worker is not in training, then $k_{t-1}$ and $k_t$ are equal to zero and wage growth is zero. If the worker is training at the same intensity both periods, ($\bar{k} = k_t = k_{t-1}$), then earnings grow at rate $g\bar{k}$. If the worker starts a training program in the $t^{th}$ year so that $k_{t-1}$ equals zero, then the training has not had a chance to have an effect on potential earnings, but reduces actual wages by the amount of training. This causes negative wage growth of magnitude $k_t$. Lastly, when a workers stops investing in training ($k_t=0$), wages grow at the rate $(1+g)k_{t-1}$ because of the effect of previous training on potential earnings and because of the end of the depressing effect of training on actual earnings.

Since longitudinal data is used it is possible to measure the wage growth of individuals. However since actual wages and not potential wages are observed, attention must be paid to the path of actual wages. It seems reasonable to assume that the period of training occurs during the first part of the job. Each job will be composed of two periods; an initial period of training followed by a non-training period. Wages may grow during the non-training period because of changing market conditions, general productivity changes, and gains from experience.

For purposes of empirical work, attention is paid to the wage growth of workers who are currently being trained. It is assumed

that the wage growth of other workers depart structurally from those currently trained. It is also assumed that for those currently being trained that the intensity of investment, $k_t$, is constant over time and among workers. This implies that potential and actual wages grow at the same rate, g or $\Delta w/w$, with each unit of time devoted to training.

However, g, the effect of training on wage growth is allowed to vary among workers. Variation in g will have effects on the return to training. Increases in the wage growth rate, g or $\Delta w/w$, will have a positive effect on the rate of return and the propensity to be trained.

The effect of training on the wages of workers, g, will depend on the effectiveness of training in augmenting the productivity of the worker. Demographic characteristics, educational preparation, ability, and occupation are likely to matter in both the effectiveness of the training program, the productivity gains experienced, and the extent that new skills can be utilized on the worker's job. The market will re-evaluate the worker's productivity and the workers wages will adjust accordingly.

Section III

Econometric Specification:

The structural model is a system of two equations: the first measuring the effect of training on wage growth and the second the determination of whether a particular worker is currently trained.

For workers who are currently being trained, wage growth is specified according to the following equation:

(7) $\Delta \ln w_i = z_i\gamma + \ell + u_i$,

where $z_i$ are a set of individual characteristics for individual i, $\ell$ is the intercept that captures the impact of market forces, productivity growth, and inflation that affect the wage growth of all workers, and $u_i$ is a random disturbance normally distributed with zero mean and variance, $\sigma_u^2$. It can be seen that this equation is equivalent to equation (6) under the assumptions that the effect of training is allowed to vary, and for those currently trained, training intensity is a constant. The important feature of this specification is that the effect of training varies systematically among workers with their measured characteristics, $z_i$, and because of unmeasured characteristics captured by the disturbance, $u_i$. The estimated expected effect of training will be $z_i\hat{\gamma}$, where $\hat{\gamma}$ is the consistent estimate of $\gamma$.

It is important to mention an advantage of using longitudinal data and concentrating on wage growth. Previous studies using this training measure have instead used cross-sectional data. Since it is impossible to measure all the factors that are important in the determination of wages, the ommission of these factors such as ability or motivation are known to cause bias in the estimates of the effect of training. It is likely that many of these unmeasured factors do not change from year to year. To the extent that these unmeasured factors are unchanging in their impact on the wage, their impact will be eliminated by concentrating on wage growth rather than wage level. Differences among workers in the determination of wages are well-controlled for, and sources of bias in the measure of the effect of training are eliminated.

The structural equation determining whether a work undergoes training is based on a comparison of the benefits and costs of the alternatives. The previous section demonstrated that the internal rate of return to an investment in training is related to the expected impact of training on the wage, the time horizon of benefits, and the costs of training. The structural equation determining training is equal to:

$$(8) \quad I = \alpha r_i + x_i b + v_i,$$

I is an indicator, positive when training occurs, non-positive otherwise, $r_i$ is the internal rate of return to training, and $x_i$ are individual characteristics that may have an impact on the determination of training. A pure economic model would have the training decision based purely on the internal rate of return. However, other characteristics may be important if individuals are being denied access to training programs because of discrimination or capital market imperfections. Thus, race and sex variables would be obvious choices for inclusion in the vector of characteristics, $x_i$. It is possible that the internal rate of return is not measured adequately because of poor predictions of the work horizon over which training benefits are received. To the extent that the work horizon is associated with the vector of characteristics, $x_i$, these variables will correct for its faulty measurement.

The internal rate of return is measured by the interest rate, r, that equates equation (2): $\Delta w(1-e^{-rH}) = rw$. Linearizing yields: $r_i = a_0 \frac{\Delta w}{w}_i + a_1 H_i$, where $a_0$ and $a_1$ are positive and H is the time horizon. Note that the percentage change in wage equals the change in the log-wage. From equation (7) the expected change in the log-wage is $z_i \cdot \gamma$. Substituting into the indicator function yields:

$$(9) \quad I = \alpha a_0 z_i \gamma + \alpha a_1 H + x_i b + v_i.$$

The indicator becomes a function of expected wage effects of training, the time horizon, and other individual characteristics. This is the reduced-form probit equation determining training.

Since the occurance of training is subject to economic decision the observation of an individual in training and its effect measured by equation (7) is endogenous. In addition, workers may differ from other workers in other ways that cause the selection of workers into training to be non-random.

There is interest in the effect of training on the wage growth of an individual worker, because it is the alternative facing a particular worker that go into the economic calculation. So care must be taken to insure that the non-random selection of trainees does not confound the measurement of the wage benefits to an individual. This is likely if ordinary least-squares regression is used to estimate equation (7). Ordinary-least squares will provide biased estimates if the disturbance is correlated with the explanatory variables. This correlation may result from the possible correlation of these variables with the likelihood of a worker being trained. Since these explanatory variables are hypothesized to be important in explaining the effects of training, they will be related to the expected economic return to training and therefore the likelihood of training.

For example, if workers who are likely to be trained have higher-wage growth, and white workers are more likely to be trained, OLS estimates would lead to an upwardly biased measure of the effects of training for whites, even if training had no effect on the earnings of whites. A method developed by Heckman (1979) will be used to reduce the extent of the sample-selection bias. Estimates of can then be interpreted as the effect of training a particular individual with certain characteristics, $z_i$.

Estimating the wage equation using ordinary least-squares would lead to biased estimates because of the correlation of the disturbance with the disturbance in the indicator function of training. This can be seen by taking the expectation of equation (7) conditional on the individual being trained.

$$(10) \quad E(\Delta \ln w_i / I>0) = z_i\gamma + \ell + E(u_i / I>0),$$

for those who are being trained. The conditional expectation will not be zero if there is non-random selection of workers into training. If the reduced-from indicator is re-written: $I = q_i\delta + v_i$, then it can be shown that the conditional expectation becomes:

$$\frac{\sigma_{uv}}{\sigma_u}\cdot\frac{\phi(-q_i\delta/\sigma_v)}{\phi(iq_i\delta/\sigma_v)}$$

where $\phi(\ )$ is the normal density function, $\Phi(\ )$ is the cumulative normal distribution, and $-q_i\delta/\sigma_v$ is the truncation point obtained from the reduced-form indicator function equation (9).

In order to estimate the model, use is made of sample-selection correction techniques. The wage equation is subject to bias because of the non-random selection of the sample into training and non-training groups. The strategy for estimation consists of several steps. First, the reduced-from training determination equation is used to create a smaple-selection correction for the structural wage equation. Lastly, the estimates of the effect of training, $\hat{\gamma}$, from the wage equation are used to estimate the structural equation of training determination by probit analysis.

The estimation of the reduced-form probit equation (9) gives estimates of $\delta/\sigma_v$ which can be used to estimate a new variable.

$$\lambda_i = \phi(-q_i\delta/\sigma_v)/\Phi(-q_i\delta/\sigma_v).$$

Including this variable into the wage-change equation (7) will correct for the sample-selection bias in the estimates of $\gamma$ and $\ell$ and give estimates of $\sigma_{uv}/\sigma_u$. If sample-selection is important then $\sigma_{uv}$ should be non-zero.

Once estimates of $\gamma$ are obtained, the wage effect of training, $r_i = z_i\hat{\gamma}$, can be calculated for the full-sample.

This can be used in the estimation of the structural probit equation (8).

Section IV

Description of the Data:

The proposed study will use as its data base, the Michigan Panel Study of Income Dynamics. The advantages of this survey are its full representation of the national population, its reliability, the eleven-year longitudinal time span, and its large sample size of about 2000 individuals. During the nineth year of the survey (1975), detailed questions on the worker's training experience have supplemented the large number of general labor market and income-related questions. These questions ask (1) whether special training is required for the job, (2) what kind of training is provided, and (3) the number of months required to learn the job. In addition, it asks whether the worker is learning skills that can not be used on the current job.

Two years of data were used from the Michigan Panel Study of Income Dynamics. Questions about training were asked in 1975, the second year of this sample. While it is possible to learn the training and work history of non-household heads, this study is restricted to household heads. This reduces the sample of women since married women are included in households headed by the husband. This limitation eliminates the complexities related to joint employment decisions.

Observations were deleted if the individual did not work in either of the two years. This may cause some sample-selection bias to the extent that employment and training are jointly determined. Other observations were deleted if there were missing or unreasonable values for hours, education, job tenure, or labor earnings.

The final sample includes 1379 observations. 19% are women, and 91% are white. This is representative of household heads.

The key variable in this study is the answer to the question asked in 1975. "On a job like yours, how long would it take the average new person to become fully trained and qualified?" This question measures the expected length of training for the particular job. It is not entirely unambiguous. For it is entirely possible that

individuals could interpret this question in terms of training on previous jobs and not training currently taking place. It is also possible that the phrase, "average new person" leads the individual into subjective guesses about other individual's capabilities. However, qualifications aside this variable provides more information on the actual training experience of the individual than can be found in most labor market surveys.

In order to make use of this information, a new variable must be constructed indicating whether training took place during the previous year. As indicated by human capital theory, training will cause increased wage growth. When training took place, the variable, T, is set equal to one, zero otherwise. This variable is constructed by comparing job tenure, TEN, with length of training, TL. If the length of training is greater than job tenure, then training occurs and T is set to one.

This construction ignores some complications. Firstly, it is possible for training to occur during the previous year but stop sometime during the year, and not be counted. Secondly, this measure may not adequately consider training on previous jobs and the loss of skills while changing jobs. It is important to note that current training is treated as a dichotomous variable and will not reflect the intensity of investment. This simplification allows the treatment of training as an endogenous variable without undo complexity.

The wage measure is found in the standard manner by taking labor earnings for the individual and dividing by annual hours of employment. The few workers with calculated wages below one dollar are assumed to have wages of one dollar. The logarithm of the wage of each year is taken. DW, the rate of wage growth is simply the difference between the log wage of subsequent years. No correction for the high rate of inflation is made, but that will be captured in the intercept of the regression. It is important to note that this wage measure will not reflect the non-pecuniary aspects of

work, such as fringe benefits and working conditions. However, to the extent that these aspects do not change between years, they will cancel out by concentrating on the change in wages.

Table 1 provides the list of variable definitions used in this study. There are variables relating to the characteristics of the individual, variables relating to the job-match, and variables relating to training. The individual characteristics include education, race, sex, marital status, region, urbanization, test scores, health limits, and the time horizon. Care was taken to include variables that are exogenous to the training decision. Other variables relate to the individual's job or employer. These are occupation, industry, and whether the worker belongs to a union. In some sense these variables are not completely exogenous to the training decision as the choice of job or employer will depend on the training involved. While the data-set has many questions about training, the only variable investigated here was whether the worker is currently being trained. This is because the correct treatment of all the dimensions of training would demand the modeling of a complex multi-alternative decision process.

Section V

Empirical Results:

The specification of the wage growth and training determination equations was estimated using the 8th and 9th wave (1974, 1975) of the Panel Study of Income Dynamics. Sample statistics are presented in Table 2 for all variables.

Approximately 20.7% of the sample were currently undergoing training Surprisingly, wage growth was greater for those who are not currently being trained. A possible explanation is that since training occurs at the very beginning of a job, trainees may be suffering from wage losses from the loss of specific-training while changing jobs. Since interest is concentrated in the effect of training on wage growth among trainee, it is the variation in wage growth and not its level that matters.

The estimated model is presented in Table 3. The first column presents the estimation of the reduced-form probit equation determining training (equation 7 of the econometric specification). The estimates suggest that being white, male, healthy, non-union, within light industry, and within certain occupations are significantly associated with being trained, while race and sex variables are in line with the results of previous studies and require little additional discussion.

The effects of the other variables are interesting. The negative impact of health limitations on training is important in light of the recent concern with the plight of the handicapped. The mechanism by which health limitations reduce earnings is illuminated as health limitations reduce opportunities for training.

The lack of training in union jobs is counter the popular image, however it is in keeping with previous studies showing slower wage growth among union workers. A possible explanation is the uniformity of the wage scales in union contracts reduce the incentive for workers to undertake on-the-job training.

The fact that heavy industries do not appear to train workers is

surprising, in light of the high demand for skilled employees in those industries. The lack of training among professionals and managers may be a sign that they obtain training by other means, through education programs perhaps.

In addition, singles, the old, and southerners were less likely to be trained though these effects were barely significant. The signs of these coefficients are consistent with one's expectations. Firms may not invest in single workers because of their greater mobility, and would not invest in old workers because of their short time horizon. Explanations of the relatively low wages of the south have often revolved around a industrial composition that has a relatively low demand for skilled and trained workers.

Surprisingly, education and a vocabulary test score, while positively associated with training, are statistically unimportant in the explanation of who gets trained. Suggestions and findings by other researchers of the strong complementarity of education with training need to be closely re-examined.

The second column presents the results of the study of the varying effects of training on wage growth among those who are trained. The variable, $\lambda$, controls for sample-selection bias in the determination of who gets trained. This variable has a positive impact on wage growth suggesting that workers who are trained are likely to experience fast wage growth for other reasons than training, but is insignificant statistically. However, its inclusion may affect the coefficients of the other explanatory variables. The $R^2$ of this equation is only 4%, however, this is reasonable considering the large amount of random noise in any measurement of wage growth. The t-statistics reported are biased because of the non-random selection, but provide a guide to the relative importance of explanatory variables.

The most important variables in the explanation of wage growth of trainees are race, marital status, and health status. The wage growth of whites, single workers, and healthy workers is much higher as may be expected.

From these estimates, the expected effect of training on wage growth, R, is calculated. This variable will vary among individuals according to their measured characteristics. It is impossible to use this variable to measure the rate of return to training but can be used to capture the variation in the rate of return among individuals. This is because market forces affecting the wage growth of all in the sample will be included in its measure. It is interesting to compare the average value of R for trainees and for non-trainees. The average R is -.076 for trainees, but only -.114 for non-trainees. The difference in the effect of training on wage growth appears important in the explanation of who gets trained from this simple comparison.

R is included in the estimation of the structural probit equation along with the time horizon, H, and these results are included in column 3. The effect of training on wage growth has a substantial positive impact on who gets trained. The t-statistic on this variable is well over 13. In addition, the time horizon variable has a positive and significant impact on who gets trained. Workers with a long time till retirement are likely to receive the benefits of training for a longer time. The structural probit equation demonstrates the importance of the economic return to training in the determination of training.

It is interesting to ask about the effect of changes in the effect of training and the time horizon on the probability of being trained. This is accomplished by multiplying the coefficients in the probit equation by the normal density function evaluated for the mean characteristics, or .34498. This implies that a one-percent change in R, the effect of training on the wage, will increase the probability of being trained by .003123. This is compared to the average probability of being trained in a year of .2074. An additional 10 years of time horizon will increase this probability by .0435. Considering the difference in average return of trainees relative to non-trainees could account for a jump in the probability of being trained of .0131. Considering

the noise in these measurements, the effect of these two explanatory variables on the probability of training is substantial.

The structural probit is also estimated along with individual characteristics that might have an additional impact on who gets training. If the characteristics of race, sex, marital status, or education are important in the determination of training when the rate of return to training is held fixed, then this suggests the operation of discrimination or market segmentation. Workers may be limited in their access to training program. An additional possibility is that the rate of return is improperly measured. For example, these individual characteristics may be associated with non-pecuniary aspects of training or discrepancies in the "true" work horizon from the approximation used here. If these individual characteristics are unimportant then we can reject the hypothesis of discrimination or market segmentation in the allocation of training.

Column 4 presents these estimates of the structural probit. While the effect of training, R, now has a greater impact than the results of column 3, it becomes less significant statistically. When the four individual characteristic variables are added to the structural probit equation, the explanatory power of the structural probit equation increases significantly as evidenced by the change in the log-likelihood ratio multiplied by negative two (from 26.7 to 66.0). More educated, non-whites, male, or married workers are more likely to be trained, given the expected rate of return. The effects of sex and marital status are both significant and large. A married worker has an extra .14438 probability of being trained over single workers. A male worker has an extra .1350 probability of being trained over a female worker. These effects are in addition to any effects created by differences in the expected rate of return.

While the race variable is not significant, it is of a sign opposite to that consistent with the simple hypothesis of discrimination. White workers are less apt to be trained, holding fixed

the rate of return. This seems to be related to the large effect of training on the wage growth of whites relative to non-whites. These results suggest that any discrimination against blacks may operate in the setting of compensation rather than through their access to training. This curious finding needs additional substantiation.

The education variable is statistically insignificant. This suggests that access to training is not improved by additional education through discriminatory behavior. It was also shown previously that education did not improve wage growth with training. The often claimed complementarity between education and training has not been found here. This is probably a result of the improved control for unmeasured individual characteristics positively associated with both training and education in longitudinal data. Add the proper controls and the effect goes away.

These results are interesting because unlike previous studies, an effort was made to control for the economic return in the determination of training. When this is done, both sex and marital status are significantly associated with training. The strong economic hypothesis is that the rate of return should be the sole determinant of training. Here it is shown that other characteristics matter. This suggests further work to refine the measure of the rate of return. However one can not easily reject the hypothesis of discrimination at this time.

Conclusions:

This study uses a new measurement of on-the-job training in order to study the effect of training on wage growth for different individuals and the determination of the propensity of training among different groups of individuals. Economic theory suggests that the decision to train a worker should be the result of a cost-benefit evaluation of alternatives. Those individuals who are likely to increase their productivity from a training program and thus have a high economic return to training should be the individuals most likely to be trained. The empirical investigation attempts an explicit test of that hypothesis by measuring the rate of return to training an individual and then investigating whether individuals with higher rates of return are indeed trained. The evidence presented here strongly supports this hypothesis, though the magnitude of the response to differences in the rate of return is not exceptionally large. Thus, the training decision appears to be based on an economic evaluation of alternatives.

However, there has been suggestions that there are alternative explanations of who gets trained. It is often claimed that the low wage growth of women and minority groups is a result of limited access to training programs because of discrimination. This hypothesis is equivalent to the suggestion that for workers with identical returns to training some workers are denied training because of their sex or race. Previous studies are unable to test this hypothesis either because of their inadequate measure of training or because of their inability to properly control for economic return. The evidence presented here suggests that women appear less likely to receive training even when the economic return to training is held fixed. It is not possible to reject the hypothesis of discrimination. Where it is also shown that unmarried individuals receive less training than would be expected based on the return to their training, there is no evidence of this type of discrimination against non-whites or the less educated. It may simply be that the source of discrimination is in the determination

of their wages rather than in their access to training. An additional finding is the lack of a strong complementarity between education and training either in education's effect on the rate of return to training or in the effect of education on the access to training programs.

These results were obtained in a sophisticated econometric model that attempted to take into account the simultaneity between the effect of training and the determination of which workers get trained. In addition, the use of longitudinal data improves the control for individual variation that may contaminate the estimates. The methodology used here should provide some additional confidence in these results.

However, there are some possible directions for an improvement and extension of this study's findings. The weakest link is perhaps the assumption that the time horizon over which benefits of training are accrued is simply the years till age 65. First, it is likely that there is wide variation in the number of years worked and the hours worked over the years of individuals. For example, it is likely that many women are likely to have irregular patterns of employment because of child-rearing. Secondly, the time horizon may vary according to the kind of training and the skills learned. Firm-specific skills are likely to have a shorter pay-back period. The variation in the time horizon of individual with the same age would cause an additional source of variation in the rate or return. A possible improvement would be to consider explicitly the labor supply and mobility decisions of individuals to provide better predictions of the time horizon. The probability of working in a given year could be predicted for an individual with certain characteristics, and used to construct an improved measure of future work years of an individual. To the extent that training creates firm-specific skills that are lost with mobility, it would be important to consider expected future labor mobility. A similar correction could be constructed for labor mobility. These refinements would improve the reliability of the measure of the rate of return.

Another direction for research would be to explore the detailed information on training in this survey. It is possible to distinguish the length of training, the formality of training, and some notion of the specificity of skills created for each individual. It would be useful to investigate the determination and effect of each of these dimensions of training.

The mechanism by which on-th-job training is allocated has important implications for policy. To the extent that training is allocated on the basis of economic return, there will be efficient uses of resources. If access is limited because of discrimination or other considerations, there are wasted opportunities. This is indicated by the exceptionally high rates of return for discriminated groups. Not only is the reduction of discrimination in the access to training important for reasons of fairness and equity, but also for considerations of productivity and efficiency. While this study demonstrated that economic considerations mattered in the allocation of training it also suggested the possible role of discrimination.

A useful extension of this study would be to use the estimates provided to evaluate the effects of various labor market policies that affect training. Obvious possibilities are tax policy, wage-subsidization plans, or the minimum wage. For it may be possible to use these estimates to measure the response of training to changes in the rate of return. To the extent that these policies affect the rate of return, they affect the determination of who gets trained.

Table 1

Definitions of Variables

| Variable Name | |
|---|---|
| DW | wage growth rate 1974-1975: log(wage 1975/wage 1974) |
| T | currently in training? (T=1 if in training, T=0 otherwise) |
| ED | education in years |
| WH | race: (WH=1 if white, WH=0 otherwise) |
| FE | sex: (FE=1 if female, FE=0 otherwise) |
| MS | marital status: (MS=1 if married, MS=0 otherwise) |
| SO | region: (SO=1 if from South, SO=0 otherwise) |
| UB | urbanization: (UB=1 if in city with over 100,000 population, UB=0 otherwise) |
| IQ | quick word test score |
| HL | health limitations: (HL=1 if health problem limits work, HL=0 otherwise) |
| UN | unionization: (UN=1 if union member, UN=0 otherwise) |
| MD | industry: (MD=1 if in durable manufacture, paper products, chemicals, construction, or transportation, MD=0 otherwise) |
| PR | professional occupation (PR=1 if professional, PR=0 otherwise) |
| CR | craft occupation (CR=1 if craftsman, CR=0 otherwise) |
| MG | managerial occupation (MG=1 if manager, MG=0 otherwise) |
| H | time horizon: 65-age |
| R | estimated percent effect of training on wages |
| $\lambda$ | estimated Mill's ratio correction for sample-selection bias |
| TL | time to learn job |

Table 2

Summary Statistics

(Standard Errors in Parentheses)

| | All | Training | Not-training |
|---|---|---|---|
| Wage 74 | 6.1869<br>(5.5791) | 6.3259<br>(5.3345) | 6.1505<br>(5.6414) |
| Wage 75 | 6.7101<br>(6.3594) | 6.4791<br>(5.1711) | 6.7705<br>(6.6353) |
| SW | .0717<br>(.4155) | .0314<br>(.5996) | .0822<br>(.3518) |
| ED | 12.1088<br>(3.1821) | 12.7098<br>(3.2503) | 11.9515<br>(3.1640) |
| WH | .9050 | .9545 | .8920 |
| FE | .1885 | .1224 | .2057 |
| MS | .7868 | .8566 | .7685 |
| SO | .3024 | .2832 | .3074 |
| UB | .5221 | .5035 | .5270 |
| IQ | 9.9659<br>(1.9349) | 10.3287<br>(1.7220) | 9.8710<br>(1.9868) |
| HL | .0696 | .0350 | .0787 |
| UN | .2705 | .1329 | .3065 |
| MD | .3611 | .2937 | .3787 |
| PR | .1784 | .1678 | .1812 |
| CR | .1899 | .1469 | .2009 |
| MG | .1196 | .1259 | .1170 |
| H | 18.8571<br>(11.3975) | 21.0000<br>(11.5701) | 18.2964<br>(11.3519) |
| $\lambda$ | -1.2548<br>(1.9120) | .3638<br>(.1901) | -1.6783<br>(2.1454) |
| TL | 2.2083<br>(2.4977) | 3.7358<br>(2.5611) | 1.8112<br>(2.4808) |
| observations | 1379 | 286 | 1093 |

Table 3

The Determination and Effect of Training
(t-statistics in parentheses)

| | DEPENDENT VARIABLES | | | |
|---|---|---|---|---|
| | (1)<br>T | (2)<br>DW | (3)<br>T | (4)<br>T |
| CNST | -1.89365<br>(5.8) | -.34688<br>(0.6) | -.97438<br>(12.3) | -1.19695<br>(4.1) |
| ED | .02305<br>(0.6) | .00402<br>(0.2) | - | .02781<br>(0.6) |
| WH | .43503<br>(3.1) | .31704<br>(1.5) | - | -.24159<br>(1.2) |
| FE | -.32511<br>(2.5) | .09018<br>(0.6) | - | 0.39146<br>(2.6) |
| MS | .21251<br>(1.6) | -.14475<br>(1.1) | - | .41853<br>(4.2) |
| SO | -.14430<br>(1.8) | -.07335<br>(0.8) | - | - |
| UB | .04574<br>(0.8) | -.03318<br>(0.4) | - | - |
| IQ | .04754<br>(0.7) | .00922<br>(0.4) | - | - |
| HL | -.44284<br>(5.4) | -.23234<br>(1.0) | | - |
| UN | -.63906<br>(10.8) | -.10899<br>(0.5) | - | - |
| MD | -.18613<br>(3.5) | -.02323<br>(0.3) | - | - |
| PR | -.47718<br>(5.3) | -.12073<br>(0.8) | - | - |
| CR | -.22511<br>(5.5) | .08822<br>(0.7) | - | - |
| MG | -.42835<br>(3.3) | .06900<br>(0.4) | - | - |
| ρ | .01144<br>(1.2) | - | .01262<br>(3.7) | .00901<br>(1.0) |
| R | - | - | .90534<br>(13.4) | 1.97046<br>(8.2) |
| λ | - | .09849<br>(0.3) | - | - |
| $R^2$ | - | .044 | - | - |
| -2·log-likelihood | 115.31 | - | 26.76 | 66.01 |
| observations | 1379 | 286 | 1379 | 1379 |

## Bibliography


Abowd, John, and Orley Ashenfelter, "Anticipated Unemployment, Temporary Layoffs and Compensating Wage Differentials," Princeton University, Industrial Relations Section Working Paper No. 137, June 1980.

Ashenfelter, O., "Manpower Training and Earnings," Monthly Labor Review, 98 (April), 46-48.

Ashenfelter, O., "Estimating the Effect of Training Programs on Earnings," Review of Economics and Statistics, 60 (February 1978), 47-57.

Bartel, Ann P., and George J. Borjas, "Specific Training and Its Effects on the Human Capital Investment Profile," Southern Economic Journal, 44 (October, 1977), 333-341.

Becker, Gary, Human Capital (second edition), New York: Columbia University Press, 1975.

Birnbaum, H., "Career Origins, On-the-Job Training, and Earnings," Southern Economics Journal, 42 (April, 1976) 587-599.

Blinder, A., "Wage Discrimination: Reduced-Form and Structural Estimates," Journal of Human Resources, 7 (Fall, 1973) 436-55.

Blinder, Alan S., and Yoram Weiss, "Human Capital and Labor Supply: A Synthesis," Journal of Political Economy, 84 (June, 1976), 444-472.

Borus, Michael E., "Measuring the Impact of Employment-related Social Programs: A Primer on the Evaluation of Employment, Training, Vocational Education, and Other Job-oriented Programs," (Up john) 1979.

Doeringer, Peter B. and Michael Piore, Internal Labor Markets and Manpower Analysis, Lexington, MA: Lexington Books, 1971.

Duncan, Greg J. and Saul Hoffman, "Training and Earnings," in Greg J. Duncan and James N. Morgan (eds.) Five Thousand American Families--Patterns of Economic Progress, vol. vi, Ann Arbor: Institute for Social Research, 1978.

Duncan, Greg J. and Saul Hoffman, "On-the-Job Training and Earning Differences by Race and Sex," Review of Economics and Statistics, LXI (November, 1979), 594-636.

Eaton, J. and H. Rosen, "Taxation, Human Capital, and Uncertainty," American Economic Review, 70 (September, 1980), 705-715.

Fleisher, B. and G. Rhodes, "Fertility, Women's Wage Rates, and Labor Supply," American Economic Review, 69 (March, 1979), 14-24.

Ginzberg, Eli, Good Jobs, Bad Jobs, No Jobs, Cambridge: Howard University Press, 1979.

Griliches, Zvi, "Estimating the Returns to Schooling; Some Econometric Evidence," Econometrica, 45 (January, 1979), 1-22.

Haley, W., "Estimation of Earnings Profiles from Optimal Human Capital Accumulation," Econometrica, 44 (November, 1976), 223-38.

Hashimoto, M, "Bonus Payments. On-the-Job Training, and Lifetime Employment in Japan," Journal of Political Economy, 87, Part 1, (October, 1979), 1086-1104.

Hause, J. C., "The Covariance Structure of Earnings and the On-the-Job Training Hypothesis," Annals of Economic and Social Measurement, 7 (Fall, 1977), 335-365.

Heckman, James, "Sample Bias as a Specification Error," Econometrica, 47:1, (Jamuary, 1979), 153-162.

Hoffman, S., "Black-White Life Cycle Earnings Differences and the Vintage Hypothesis: A Longitudinal Analysis," American Economic Review, 69 (December, 1979), 855-867.

Holtmann, A.G., "On-the-Job Training, Obsolescence, Options and Returning," Southern Economics Journal, 38 (January, 1972), 414-417.

Holtmann, A. G. and Smith, V. K., "Uncertainty and the Durability of On-the-Job Training," Southern Economics Journal, 44 (July, 1977), 36-42.

Holtmann, A. G. and Smith, V. K., "Uncertainty and the Durability of On-the-Job Training, an Extension," Southern Economics Journal, 45 (January, 1979), 885-57.

Lazear, E., "The Narrowing of Black-White Wage Differentials Is Illusory," American Economics Review, 69 (September, 1979), 553-564.

Lecht, Leonard, et. al., Changes in Occupational Characteristics: Planning Ahead for the 1980's. New York: The Conference Board, 1976.

Maton, J., "Experience on the Job and Formal Training as Alternative Means of Skills Acquisition: An Empirical Study," International Labor Review, 100 (September, 1969), 239-255.

Mincer, Jacob, Schooling, Experience, and Earnings, New York: Columbia University Press, 1974.

Mincer, J. and S. Polechek, "Family Investment in Human Capital: Earnings of Women," Journal of Political Economy, 82 (March/April, 1974), S76-S108.

A Panel Study of Income Dynamics: Procedures and Tape Codes 1976 Interviewing Year, Ann Arbor: Institute for Social Research, 1976.

Rosen, Sherwin, "Learning and Experiences in the Labor Market," Journal of Human Resources, 7 (Summer, 1972), 326-342.

Ryder, H., F. Stafford, and P. Stephan, "Labor, Leisure, and Training Over the Life-Cycle," International Economic Review, 17 (October, 1976), 651-674.

Sandell, S. and D. Shapiro, "The Theory of Human Capital and the Earnings of Women: A Re-examination of the Evidence," Journal of Human Resources, 13 (Winter, 1978), 103-117.

Smith, J. and F. Welch, "Black-White Wage Ratios: 1960-1970," American Economic Review, 67 (June, 1977), 323-338.

Smith, J.P. and F. Welch, "Race Differences in Earnings: A Survey and New Evidence," R-2295-NSF, Rand Corp., March 1978.

Welch, F., "Black-White Differences in Returns to Schooling," American Economic Review, 63 (December, 1973) 893-907.

Willis, R. and S. Rosen, "Education as Self-Selection," Journal of Political Economy, 87 (October, 1979), S7-S37.